THE GENERAL PRINCIPLES OF NUTRITION.

A LECTURE DELIVERED AT BURY ST. EDMUNDS.

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ALTHOUGH the title of my address is "The General Principles of Nutrition" it will I believe be in accordance with your expectations if I emphasize their special application to the case of the infant and child. In these instances it is particularly important that these principles should be strictly observed, for the reason that during early life the growth and development of the body, as well as its maintenance, are dependent upon a correct supply of all the necessary materials, whereas in later life, when growth and development are complete, the body is only dependent on its food supply for maintenance and repair. Mistakes made during the developmental period are permanent and irremediable.

When, about the middle of the last century, a growing knowledge of the simple laws of chemistry and physics allowed the subject of dietetics to be viewed from the scientific standpoint, mechanistic explanations were propounded by physiologists to interpret the working of the animal body on the basis of the "laws of the conservation of energy," laws which were known to hold true in the case of the mechanical engine. In the same way that the potential energy-value of fuel could be utilized by the mechanical engine, and converted into heat or work, it was explained that the animal engine could utilize food materials and turn out an equivalent value of heat and energy. With great patience the potential energy values or, as we now term them, the caloric values, of all varieties of food were estimated, and at the same time the output of work of different individuals, as estimated in food-pounds or kilogrammemetres, was calculated with the greatest nicety, and the optimistic physiologists of that day were well satisfied that they had solved the main problems of dietetics when they supplied the animal organism with food of sufficient caloric value to balance the required units of kinetic energy necessary for the daily work.

If a man had to do so much mechanical labour, or put out so many food-pounds of work, he had to take into his system an equivalent of potential energy. By "the laws of the conservation of energy" his output was determined by his intake; with a given supply he could put out no more or no less work than was represented by the actual value in potential energy of his food. So far, the accordances of the animal with the mechanical engine were indisputable, but it was not long before the difficulties of the problem began to multiply, and certain apparent pitfalls in this simple interpretation of the laws of dynamics in the case of the animal machine began to present themselves; for instance, it was noticed that strict adherence to the quantitative supply did not maintain the organism in health unless the qualitative side was also taken into consideration. Pettenkofer and Voit, who were pioneers in these early attempts to place dietetics in a scientific basis, were most dogmatic in their views on "balance," i.e., the physiological ratio of the three elements which alone at that time were taken into serious consideration — namely, proteins, carbohydrates and fats.

The necessity of arranging the food or fuel on a mixed basis did not, however, seriously invalidate the analogy between the food of the living organism and the fuel of an inanimate machine, for it had to be admitted that different machines were adapted to the consumption of different varieties of fuel, and some even required special mixtures; while all worked with the greatest efficiency when some particular optimum quality or mixture was provided. What however was not understood at that particular period in the history of scientific dietetics was that *food* subserved many functions in the animal organism which *fuel* did not subserve in the case of the mechanical machine. No mechanical engine will run satisfactorily or automatically without the special attentions of the engineer. It must be lubricated, cooled, cleaned, controlled, adjusted and driven by the guiding hand of the mechanic with all sorts of accessory materials to aid him in his work; whereas the animal engine runs automatically without such attentions, provided only that the food which is stoked into its furnace contains the *raw materials* out of which the essential lubricators, regulators, accelerators, depressors, and electromotive forces can be manufactured.

To stoke the animal engine with all the varieties of raw material which are required for its many automatic functions, an immense number of different elements or proximate principles are required. In milk itself, which may be regarded as a complete food, there are more than forty different elements, and any food which is to replace milk, or supply all the necessities of nutrition must contain a similar number of elementary components. None of these elements are redundant or unnecessary, and although Nature in her efforts to compound an absolutely perfect food for the developing offspring of the mammal may not have achieved entire success, none the less the most searching scrutiny, in the light of present-day knowledge, has not been able to discover any serious mistake. The examination of the chemical make-up of milk shows that the following components are represented in various proportions :—

TABLE I.

More than forty elements or proximate principles are required for adequate nutrition. There are more than fifty in milk.

CONSTITUENTS IN MILK.

Proteins	at least	3	in number
Sugar (lactose)	,,	1	,,
Fats and fatty acids ...	,,	6	,,
Vitamins	,,	5	,,
Mineral elements in salts	,,	18	,,
Extractives	,,	8	,,
Gases	,,	4	,,
Aromatic bodies ...	,,	(?)	,,
Antibodies, Precipitins, Agglutinins	,,	6	,,
Colouring matter, Lipoids ...	,,	(?)	,,
Ferments	,,	10	,,
Total ...		61	

It is impossible to appraise the respective values of these several elements in order of importance, but there are few of them which can be omitted without detriment to nutrition, or without some risk of immediate or deferred death. In the entire absence of proteins, carbohydrates, fats, vitamins, mineral elements or water, a fatal result is merely a matter of time. If supplied in deficient or excessive amount, normal nutrition will be interfered with to a greater or less extent. No argument is required to convince even the sceptic that for every one of those forty or fifty essential elements in nutrition there must be an optimum supply —an optimum which is not fixed or arbitrary, but dependent upon many associated factors, as, for instance, on individual metabolism, work, temperament, and environmental conditions.

The standard of nutrition and health of whole nations, of families and individuals, depends on the degree of success or failure with which these requirements are met. Some nations, some families, some individuals, have stumbled by accident or necessity on a combination of foods which have fulfilled the conditions of what within limits we may call an optimum dietary, and in consequence have prospered exceedingly. Other nations have been less successful; our own, during the revolutionary period of urbanization—the conversion of a pastoral and agricultural people into a race of "shopkeepers" and "manufacturers"—has suffered extensively, and following the paths of least resistance has lighted upon a national dietary which has been exceedingly defective in many important respects, and capable only of maintaining nutrition at a very low standard.

Many years ago the great chemist, Baron von Liebig, in a very comprehensive manner included some of the most important principles of nutrition, as we now understand them, in his "Law of the Minimum." This law, simply explained, is as follows: With any given combination of foods the maximum degree of nutrition which can be reached is limited by the greatest defect. To take an example, if you compound a milk modification for a baby which affords an optimum representation of all the elements essential for nutrition save one, let us say, vitamin C, in spite of the general excellence of the food, the infant will thrive no longer than is allowed by the absence of this essential vitamin, that is to say, for a few months; after that it will begin to waste away and develop symptoms from which it will ultimately succumb.

What is true of elements such as vitamins is also true of all those in a complete dietary. In the absence of iron, iodine, sodium, potassium, magnesium, and many other similar elements, life can only be maintained for a short period, no matter how correct be the diet in all other respects. This "Law of the Minimum" is fundamental in all dietaries, and explains a vast number of the failures in the feeding of infants and children which on other accounts is inexplicable.

In the light of Liebig's "Law of the Minimum," the great importance of the imponderabilia of diet, the little unconsidered trifles, such as iodine, iron, vitamins, cholesterol, lecithin, &c., are easily explained. We can see what grievous mistakes can be made when cow's milk modifications are substituted for breast milk. When cow's milk is modified with the object of rendering it an equivalent for breast milk, it is usually diluted with an equal amount of water. Such dilution reduces the representation of all its contained elements by 50 per cent., and hence, unless cow's milk contains twice as much of all its constituents as breast milk does, such a dilution would be entirely unsuitable. As a matter of fact, cow's milk does not contain a larger representation than breast milk of any important element, except perhaps casein and phosphate of calcium. Thus infants who are fed on diluted cow's milk are cheated of half their rights of practically every important constituent. To compensate for some of the recognized defects caused by such dilution, it is usual to add a little cream, a little sugar, and perhaps a little orange juice and cod-liver oil. Such additions are given independently, or in combination with diluted milk, and are of course rational and correct, but they do not compensate for the shortage of many other equally important elements, such as iron, iodine, sodium, phosphorus, cholesterol or lecithin.

If infants were fed on whole milk instead of milk dilutions, they would not be starved in respect of the great majority of necessary elements, but they would be grossly overfed with casein, since cow's milk contains 300 per cent. more of this element than breast milk, and since excess of casein brings troubles of its own almost as great as those brought about by deficiency of other elements, undiluted cow's milk cannot be regarded as a solution of the problem. Although I do not propose to enter upon the question of the correct modification of cow's milk in the feeding of infants, I may perhaps say this much, that if whey be used for diluting milk instead of water, most of the objections on the score of deprivation of essential elements are avoided.

(*To be continued*).